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Author contributions

NK and JL contributed to the design of the study, assisted with data analysis and participated in critical revision of the manuscript. JS performed the data analyses and drafted the manuscript. EM, OP and OR were involved in interpreting results and critically reviewed the manuscript. All authors read and approved the final manuscript as submitted.

Associations of changes in diet and leisure-time physical activity with employer's direct cost of short-term sickness absence

Abstract

Several unhealthy lifestyles are associated with increased sickness absence (SA). This study examined the associations of changes in diet and leisure-time physical activity (LTPA) with employer's direct cost of subsequent short-term (< 10 working days) SA. The survey data from phases 1 (2000−02) and 2 (2007) of the Helsinki Health Study (HHS), a longitudinal cohort study of initially 40−60-year-old employees of the City of Helsinki, Finland, were linked with SA register data. Final data consisted of 4157 employees. Dietary habits were inquired with a short food frequency questionnaire. Consumption of fruits (F) and vegetables (V) was used to indicate healthiness of diet. LTPA was measured with a series of questions on the intensity and the amount of LTPA. Data on short-term SA and salaries (2008−12) were received from the employers' registers. A two-part model was used to analyse the associations. Those who improved their F&V consumption from non-daily to daily and persevered physically active got 620 € (95% CI -1194, -47) lower cost than those remaining non-daily F&V consumers and physically inactive. When examining LTPA only, those who persevered physically active or improved from moderately active to active got 19% less cost for the employer than those remaining inactive. Dietary changes were not independently associated with the cost. Improving employees' diet and LTPA may reduce employer's direct cost of SA. Although the associations of diet with SA cost were not statistically significant, improvements in diet may contribute to the beneficial associations of LTPA and employer's cost of SA.

Keywords

Cost, Diet, Employees, Leisure-time Physical Activity, Sickness Absence, Worksites

Introduction

Unhealthy diet and physical inactivity contribute to chronic diseases, thus causing economic burden in societies (Candari, Cylus, & Nolte, 2017). The estimated annual healthcare cost range for unhealthy diets is 3−148 € and for physical activity (PA) 3−181 € per capita (Candari et al., 2017). On average, unhealthy diet and physical inactivity are attributable to approximately 2% of the total healthcare costs (Proper & van Mechelen, 2008). In addition, unhealthy lifestyles and lifestyle-related common diseases are associated with weakened work ability and productivity, and increased sickness absence (SA) (van den Berg, Burdof, & Robroek, 2017; Leijten et al., 2014; Robroek, van den Berg, Plat, & Burdof, 2011), which lead to additional cost also for the employers. Our previous study (Kanerva, Pietiläinen, Lallukka, Rahkonen, & Lahti, 2018) found that several unhealthy lifestyles may increase the direct cost of short-term SA to the employer by up to 30%.

Previous studies have shown that physical inactivity is associated with increased SA (Kerner, Rakovac, & Lazinica, 2017) and their cost (Tolonen, Rahkonen, & Lahti, 2017), but the role of diet in SA is still unclear. Some diet-related factors, including obesity, high blood glucose and blood pressure, have been shown to increase SA cost (Kowlessar, Goetzel, Carls, Tabrizi, & Guindon, 2011). There may also be joint associations of diet and PA with SA as diet and PA have both separately and together several positive effects on health (G.A. Kelley & Kelley, 2012; Walker, O'Dea, Gomez, Girgis, & Colagiuri, 2010; Davies, Batehup, & Thomas, 2011). Improving employees' diet and PA may prevent SA cost, but studies on the effects of lifestyle changes on SA are lacking. The estimated cost of SA in the European countries is 2.5% of GDP (Edwards & Greasley, 2010).

In general, costs are divided into direct, including salary and replacement cost, and indirect cost, including decreased production and management cost. Data on short-term SA are not often available due to lack of comprehensive registers, which is one reason for the lacking evidence. Short-term SA have been shown to predict subsequent SA due to ill-health they reflect (Hultin, Lindholm, Malfert, & Möller, 2012). Thus, early recognition of the risk factors beyond short-term SA may have significant, far-reaching health and economic consequences.

This study aimed to investigate the associations of changes in diet and leisure-time physical activity (LTPA) with employer's direct cost of subsequent short-term (< 10 working days) SA. Employer's comprehensive register of SA data and individual salaries were used to estimate the real cost of SA among midlife and ageing employees of the City of Helsinki.

Materials and Methods

Study Design, Setting and Participants

The Helsinki Health Study (HHS) invited all 40–60-year-old employees of the City of Helsinki, Finland, to participate the survey of 2000−02 (phase 1) (Lahelma et al., 2013). The sample consisted of 13 346 employees, with 67% responding (*n*= 8960). Phase 1 respondents received a similar follow-up questionnaire in phase 2 (2007), with 83% responding (*n*= 7332). Data from 2000 to 2007 were used to examine the changes in diet and LTPA. The survey data were linked with employer's personnel registers providing the information on short-term SA, salaries and employment time (2008−12), by using unique personal identification number given to each Finnish citizen. Those not consenting to linkage (*n*= 1449) and those no longer employed by the City of Helsinki (*n*= 1726) were excluded. The final data consisted of 4157 employees. The HHS protocol was approved by the ethics committees of the Department of Public Health, University of Helsinki and the health authorities of the City of Helsinki.

Measures

Cost of Sickness Absence

Individual annual gross salary data from the employers' personnel register were used to calculate the cost of short-term SA (< 10 working days). Salaries were first converted to 2012 earnings level using local government wage and salary indices (Statistics Finland, 2018). Then, participant's average daily earnings for each follow-up year were calculated: the individual annual salary was divided by participant's employment months, and then divided by 21. The number of annual short-term SA days was multiplied with the daily salary of the particular year. For total SA cost per individual, annual costs between 2008 and 2012 were summed.

Diet

Food frequency questionnaire (FFQ) included 20 questions about different foods consumed during the past four weeks. There were seven frequency alternatives to choose from, varying from "not at all during the past 4 weeks" to "twice a day or more". Participants' fruit and vegetable (F&V) consumption was classified into three groups based on the Finnish nutrition recommendations (The National Nutrition Council of Finland, 2014): consuming neither F nor V daily, consuming either F or V daily and consuming both F and V daily. F&V consumption variables from phases 1 and 2 were combined into a 9-group variable reflecting change. Dark bread consumption was dichotomised into non-daily (5−6 times a week or less) and daily (once a day or more) and thus, the change variable consisted of four groups. Meat consumption was dichotomised into participants consuming meat or meat products moderately (2−4 times a week or less) and frequently (5−6 times a week or more). The combined change variable in meat consumption consisted of four groups.

In addition to FFQ, there were two questions about the fat products used as bread spread (6 alternatives) and in cooking (10 alternatives). Each alternative was categorised either into vegetable-oil-based or animal-based fats. Participants choosing vegetable oil-based fats both for spread and cooking formed a group of “vegetable oils”, participants choosing animal-based fat either for spread or cooking formed a group of “mixed fats” and participants choosing animal-based fat both for spread and cooking formed a group of “animal fats”. Consequently, the change variable consisted of nine groups. If the responder had missing data or more than one chosen alternative concerning a food habit in question (F&V *n*= 71, dark bread *n*= 56, meat *n*= 63 and fat *n*= 441), the answer was marked as zero, corresponding to not meeting the recommendations.

Physical Activity

Leisure-time physical activity (LTPA) was measured with a question on the frequency and intensity of exercise in leisure-time or commuting during the past 12 months. The intensity of exercise included four grades: walking, brisk walking, jogging and running or equivalent activities. In addition, average weekly hours in each intensity grade were asked with five alternatives from “not at all” to “four hours or more”. From these questions, metabolic equivalent (MET) index was constructed. The total weekly MET-hours were calculated by multiplying the estimated MET value of each intensity grade (Kujala, Kaprio, Sarna, & Koskenvuo, 1998) by the time used and combining the MET-hours of four intensity grades (Lahti, Lahelma, & Rahkonen, 2012). Then, respondents were classified into three groups both in phases 1 and 2: inactive (< 14 MET-hours week^{-1}), moderately active (≥ 14 MET-hours week^{-1} including the two lowest intensity grades) and active (≥ 14 MET-hours week^{-1} the two highest intensity grades) (Lahti et al., 2012). Consequently, the change variable consisted of nine groups. If the responder had missing data (*n*= 54), the response was marked as zero, corresponding to the lowest activity level.

Joint – Diet and Physical Activity

The joint variable of diet and PA consisted of changes in F&V consumption and LTPA. F&V consumption was chosen to the joint variable to indicate the healthiness of participants' diet. Changes in dark bread and meat consumption and in quality of fat, and their associations with employer's direct cost of SA were also investigated, but their independent associations were more inconsistent than the associations of changes in F&V consumption and cost. Instead of 9-group change variables, in order to get a reasonable number of groups to the joint variable, we used 4-group change variables for both F&V consumption and LTPA. In F&V consumption, this means that only those who consumed both F&V daily were included in the group of daily consumers, and the rest into the non-daily consumers. LTPA was estimated as described above, though combining the groups of moderately active and active. Consequently, the joint variable consisted of 16 groups.

Covariates

To control for confounding, information on participants' age, gender, work years, prior SA days during the year before 5-year SA follow-up period, occupational position, marital status, smoking, binge drinking, sleeping hours and occupational physical workload were used. Data on participants' work years, prior SA days and occupational position were received from the employers' registers whereas other covariates were derived from the phase 2 questionnaires. Occupational position included four classes: professionals or managers, semi-professionals, routine non-manuals and manual workers. Marital status was classified into those in relationship and those not in relationship. Smoking status was classified into non-smokers and current smokers. Alcohol use was classified into no binge drinking (those answering "never") and binge drinking (all others). Sleeping hours were classified into 7−8 hours and < 7 or > 8 hours a day. Occupational physical workload was classified into heavy or light according to the response to a question on how physically strenuous the respondent found their work.

Statistical Analysis

Descriptive analyses by different background, dietary and LTPA groups were performed among all participants and separately among those who had SA (Tables 1 and 2). To estimate participants' short-term SA and their cost, mean and standard deviation (SD) were calculated. A two-part model was used to analyse the associations of changes in diet and LTPA with the cost. Each dietary and LTPA variable was investigated separately from each other. The probability of having short-term SA among all participants was analysed first using generalised linear model with binomial regression. Then, the associations of changes in diet and LTPA with the SA cost were analysed among employees who had short-term SA during 2008−12, using generalised linear model with gamma distribution and log-link function. To control for confounding, both analyses were first adjusted for age, gender and work years (Model 1) and then additionally, for other covariates (Model 2). Finally, marginal effects were evaluated at covariate means to estimate the cost in euros. As a sensitivity analysis, all statistical tests were redone by excluding those with missing information in F&V or LTPA variables. The results of the sensitivity analysis did not differ from the main results. Also, the associations of changes in diet and LTPA with short-term SA days were examined, and the results were similar with the results concerning SA cost. All analyses were performed using IBM SPSS Statistics version 22 and STATA version 15.

Results

Of all participants, 84% (*n*= 3510) had at least one short-term SA spell during the 5-year follow-up (Table 1). Participants who had unhealthier lifestyles in terms of smoking, alcohol use and sleeping had more SA days and got higher cost for the employer than those with healthier lifestyles. Table 2 shows the descriptive statistics of short-term SA and their direct cost in dietary and LTPA change variables among all participants and among those who had short-term SA during the follow-up (see Table S1 for fat, bread and meat variables). Concerning change in F&V consumption, the most SA days and the highest cost were among those who did not consume F&V daily over the 5-year follow-up. Concerning change in LTPA, the most SA days and the highest cost were among those who decreased their LTPA from moderately active to inactive (Table 2).

[Table 1 and 2 near here].

Cost estimates for the contribution of changes in diet and LTPA on employer's direct cost of short-term SA, based on two-part model are shown in Table 3. Supplementary table 2, with the complete results of the two-part model, shows that changes in F&V consumption and LTPA were not associated with having short-term SA among all participants (Model 2, logistic regression). In dietary changes, statistically significant associations with SA cost were found only for change of F&V consumption, when adjusting for gender, age and work years (Table 3, Model 1), whereas changes in fat quality, dark bread and meat consumption were not statistically significantly associated with the cost (see Table S3). In general, increasing F&V consumption or persevering frequent F&V consumption got lower cost of short-term SA compared to those who did not report daily F&V consumption over the follow-up (Table 3, Model 1). After adjusting for more covariates (Table 3, Model 2), however, no statistically significant results were found. Concerning change in LTPA, persevering physically active got 898 € (95% CI -1331, -464, $p < 0.001$) and improving from moderately active to active got 857 € (95% CI -1345, -369, $p = 0.001$) lower cost compared to those who persevered inactive (reference group) (Table 3, Model 1). The mean cost among reference group was 3609 € (95% CI 3226, 3992). The results attenuated but remained statistically significant after adjusting for more covariates (Table 3, Model 2).

[Table 3 near here].

The joint associations of changes in diet and LTPA with the SA cost have been illustrated in Figure 1. The figure shows the estimated cost in different joint groups compared to those who remained non-daily F&V consumers and physically inactive (reference group) over the follow-up. Changing from non-daily to daily F&V consumer and persevering physically active was associated with 620 € (95% CI -1194, -47, $p = 0.034$) lower cost compared to the reference group (mean cost 3479 €, 95% CI 2989, 3969). Furthermore, those persevering in daily F&V consumption and physically active got 507 € (95% CI = -1036, 21, $p = 0.060$) lower cost than the reference group. The highest cost for the employer got those who decreased their F&V consumption from daily to non-daily and remained inactive, but the association was not statistically significant.

[Figure 1 near here].

Discussion

This study showed that maintaining a healthy diet and a physically active lifestyle as well as improvements in these may decrease employer's direct cost of short-term (< 10 working days)

SA. F&V consumption was used to indicate the healthiness of participant's diet in general. Employees who increased their F&V consumption from non-daily to daily and persevered physically active got 620 € less cost than those remaining non-daily F&V consumers and physically inactive. When examining only LTPA, the lowest cost for the employer got those who either persevered physically active or increased their activity level from moderate to active, both with 19% reduction of cost compared to those remaining inactive. Also, in dietary changes, there was a tendency that those who increased their F&V consumption or maintained a greater F&V consumption got the lowest cost, but no statistically significant results were found after adjusting for several background factors.

Studies on changes in diet and LTPA and their associations with SA cost has been very limited. Our study showed that not only having healthy lifestyles but also improving them may decrease SA cost for the employer. The associations were clearer and stronger when the employee shifted from semi-healthy to the healthiest group of diet or LTPA, compared to those with slighter improvements. For example, improving from non-daily F&V consumption to consume F or V daily, as well as increasing LTPA level from inactive to moderate, did not get significantly lower cost compared to those with continuously unhealthy lifestyles. Similarly, in a previous study using the same data (Lahti et al., 2012), employees who raised their LTPA level from inactive to vigorous had a significantly lower risk for both shorter and longer SA compared to those remaining inactive, whereas increasing LTPA level from inactive to moderate did not decrease the risk significantly. In our study, being physically active in phase 1 seemed to protect from further SA cost despite of decreases in LTPA. The results may reflect participant's earlier, possibly long-term good fitness status rather than the effect of change, as we do not know participant's LTPA status before phase 1.

Previous studies have shown that being physically active may decrease employee's SA (Kerner et al., 2017) and their cost for the employer (Tolonen et al., 2017) compared to those who are less active, whereas the associations of diet with SA are still unclear (Robroek et al., 2011; Fitzgerald, Kirby, Murphy, & Geaney, 2016). Our results are in line with these findings. The beneficial effect of PA on SA may be partly explained by the preventive impact of PA on musculoskeletal disorders which are one of the major causes of SA (Haukka et al., 2013; van Amelsvoort, Spigt, Swaen, & Kant, 2006). PA, especially moderate activity, may also enhance immune function (Romeo, Wärnberg, Pozo, & Marcos, 2010), which could lead to decreased short-term SA. Short-term SA has been shown to be associated especially with minor and common illnesses such as respiratory disorders, headache and gastroenteritis (Feeney, North, Head, Canner, & Marmot, 1998). The potential effect of diet on short-term SA may relate to the capacity of F&V to modify antioxidant pathways and immune system (Lampe, 1999).

Although the changes in diet were not independently associated with the cost, the joint associations of healthy diet and PA may produce cost savings for the employer. The joint associations may be partly explained by weight changes as the beneficial effects of diet and PA changes on health are often related to that. For example, the beneficial effects of improvements in diet and PA on blood lipid metabolism (GA Kelley & Kelley, 2012) and some cancers (Davies et al., 2011) have been perceived to be explained by weight change. Moreover, previous studies have shown that obesity is strongly associated with SA (K Neovius, Johansson, Kark, & Neovious, 2009). Nevertheless, in addition to weight control, improving diet and PA have several other beneficial effects on individual's health, e.g. through decreased blood pressure and blood glucose, which may further decrease employer's cost (Kowlessar et al., 2011).

Strengths and Limitations

The strength of this study is the large data set with identical questions on LTPA and diet in phases 1 and 2. The response rates in phases 1 (67%) and 2 (83%) were at least satisfactory, and the characteristic differences between responders and non-responders were relatively minor (Lahelma et al., 2013). Thus, the HHS cohort participants represent well the target population, middle-aged municipal employees in Finland (Laaksonen et al., 2008). Participants who were older, in higher occupational classes and with shorter SA tended to be more likely to respond in phase 1. The cohort is not representative of the Finnish general population, e.g. as women's proportion in the cohort is large (Lahelma et al., 2013). Comparison between countries may be challenging because of differences in legislation, different methods of measurements and definitions of short-term SA. However, the average number of short-term SA days an employee takes in Finland is at the average level among EU countries (Parent-Thirion, Macías, Hurley, & Vermeylen, 2007).

Employer's comprehensive registers on employees' short-term SA and individual annual gross salaries enabled us to estimate the associations of diet and LTPA with employer's real cost, which are rarely investigated. Data of short-term SA are not often available because of lack of the registers, or the data are derived from employees' self-reporting health questionnaires which may be inaccurate. In addition, we were able to control for several covariates that associate with SA, F&V consumption and LTPA. The design of our study was prospective, looking first at changes in diet and LTPA in approximately 5-year interval (phase 1−2007) and examining the association of these changes with cost of short-term SA occurring during the next 5-year interval (2008−12). This design gives some suggestion about the direction of the association between F&V consumption, LTPA and SA. As changes in F&V consumption and LTPA may be indicative of participant's health status, we aimed to control this confounding at least partially by adjusting for SA that occurred during one year before the SA follow-up (2008−12).

It needs to be acknowledged, however, that the direct salary cost form only a part of the total cost of short-term SA that changes in diet and LTPA may provide to the employer. Unhealthy diet and physical inactivity may increase also other direct and indirect cost for the employer, e.g. through reduced productivity at work, hiring substitutes and medical care cost. Insufficient F&V consumption has been associated with a degree of productivity loss at work (Robroek et al., 2011) and inadequate PA with increased medical care cost and presenteeism (Kowlessar et al., 2011; Walker, Tullar, Diamond, Kohl, & Amick, 2017). To evaluate the effect of changes in diet and LTPA on the total cost for the employer, all the direct and indirect costs should be estimated.

There are several challenges in investigating changes in diet and PA. First, the information of changes in participants' diet and LTPA is based on participants' self-reports only in two different time points and may therefore not represent real change. Secondly, we cannot know when and in which timespan the changes of diet and LTPA have occurred. The effect of change in diet or LTPA may be different, if the employee has changed his/her lifestyle habits gradually over the 5-year follow-up compared to sudden change in the beginning or in the end of the follow-up. In addition, we do not know participants' background before phase 1 concerning diet and LTPA, which may have a remarkable effect on participant's current health and the impact of change. Changes in diet and PA may also yield such longitudinal effects on health and cost, e.g. through weight loss, which appear after a longer timespan than we had in our study.

F&V consumption and LTPA are derived from self-reports, which potentially results in reporting bias, especially as F&V consumption and PA are often overestimated. We used frequency of F&V consumption to indicate the healthiness of diet, which may only partly represent the real healthiness of diet. Firstly, participants with daily F&V consumption do not necessarily meet the nutrition recommendations, if F&V portion sizes are small. Participants' diet could be estimated more precisely if we had information on the amount of F&V consumption in addition to frequency. That could yield also stronger estimates of SA cost for diet. Secondly, the healthiness of diet consists of adequate F&V consumption together with other healthy dietary choices. On the other hand, in previous studies concerning SA, both F&V consumption and dietary indices are used to measure the healthiness of employee's diet, and the results vary in both cases (Robroek et al. 2011; Fitzgerald et al., 2016). In addition, self-report PA questionnaires have demonstrated good reliability while no single type of PA questionnaire has proven superior (Silsbury, Goldsmith, & Rushton, 2015; van Poppel, Chinapaw, Mokkink, van Mechelen, & Terwee, 2010).

Conclusions

Improving employees' diet and LTPA may reduce employer's direct cost of SA. We found that employees who improved their F&V consumption from non-daily to daily and persevered physically active caused significantly lower cost of short-term (< 10 working days) SA spells to the employer than those remaining non-daily F&V consumers and physically inactive through the 5-year follow-up. Furthermore, employees who persisted physically active or improved their activity from moderate to active got one-fifth lower cost for the employer than those remaining inactive. To estimate the total cost savings which improvements in diet and LTPA may produce for the employer, the effect of other direct and indirect cost should also be evaluated.

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Declaration of Interest Statement

The authors declare that they have no competing interests.

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Appendices

Table 1. Short-term sickness absence and their direct cost (€) of short-term sickness absence for the employer over the 5-year follow-up by participants' background characteristics.

	All participants (*n*= 4157)			**Those who have short-term SA (*n*= 3510)**		
	Mean (SD) or *n* (%)	**SA days (mean, SD)**	**SA cost (mean, SD)**	**Mean (SD) or *n* (%)**	**SA days (mean, SD)**	**SA cost (mean, SD)**
Age (mean, SD)	53.9 (5.7)			53.3 (5.4)		
Gender (*n*, %)						
Women	3477 (83.6)	28 (0.6)	3645 (73)	3009 (85.7)	32 (0.6)	4210 (79)
Men	680 (16.4)	17 (0.9)	2757 (138)	501 (14.3)	23 (1.1)	3762 (167)
Occupational position (*n*, %)						
Professionals/managers	1300 (31.3)	16 (0.6)	3051 (118)	984 (28.0)	21 (0.8)	4030 (142)
Semi-professionals	876 (21.1)	24 (0.9)	3501 (135)	761 (21.7)	28 (1.0)	4037 (146)
Routine non-manuals	1470 (35.4)	33 (1.0)	3886 (112)	1322 (37.7)	37 (1.0)	4320 (118)
Manual workers	511 (12.3)	33 (1.7)	3538 (176)	443 (12.6)	38 (1.8)	4076 (189)
Marital status (*n*, %)						
In relationship	2917 (70.2)	24 (0.6)	3344 (75)	2452 (70.2)	29 (0.6)	3982 (84)
Not in relationship	1221 (29.4)	30 (1.0)	3869 (127)	1042 (29.8)	35 (1.1)	4530 (138)
Smoking (*n*, %)						
Non-smoker	3189 (76.7)	23 (0.5)	3219 (70)	2643 (75.8)	28 (0.6)	3883 (78)
Current smoker	942 (22.7)	36 (1.3)	4453 (158)	843 (24.2)	40 (1.4)	4977 (167)
Alcohol use (*n*, %)						
No binge drinking	1751 (42.1)	23 (0.7)	3120 (92)	1449 (41.3)	28 (0.8)	3776 (103)
Binge drinking	2406 (57.9)	28 (0.7)	3777 (90)	2061 (58.7)	33 (0.8)	4408 (98)
Sleeping hours (*n*, %)						
7-8h	3045 (73.2)	26 (0.6)	3483 (73)	2598 (75.3)	30 (0.6)	4084 (80)
<7h or >8h	1045 (25.1)	27 (1.1)	3546 (140)	854 (24.7)	33 (1.2)	4335 (159)
Occupational physical work load (*n*, %)						
Light	2741 (65.9)	22 (0.5)	3282 (77)	2272 (65.2)	27 (0.6)	3959 (87)
Heavy	1384 (33.3)	33 (1.0)	3931 (118)	1212 (34.8)	38 (1.1)	4498 (127)

Abbreviations: SA; sickness absence, SD; standard deviation.

Table 2. Short-term sickness absence and their direct cost (€) of short-term sickness absence over the 5-year follow-up by changes in diet and physical activity.

	All participants (*n*= 4157)			**Those who have short-term SA (*n*= 3510)**		
	***N* (%)**	**SA days (mean, SD)**	**SA cost (mean, SD)**	***N* (%)**	**SA days (mean, SD)**	**SA cost (mean, SD)**
Change in F&V consumption						
Continuously neither daily	445 (10.7)	30 (2.0)	3983 (229)	382 (10.9)	35 (2.1)	4640 (252)
Neither daily to other daily	306 (7.4)	28 (2.1)	3800 (261)	261 (7.4)	33 (2.4)	4455 (287)
Neither daily to both daily	203 (4.9)	28 (2.1)	3442 (241)	174 (5.0)	33 (2.3)	4016 (256)
Other daily to neither daily	265 (6.4)	30 (2.0)	3926 (257)	227 (6.5)	35 (2.2)	4583 (227)
Continuously other daily	511 (12.3)	27 (1.4)	3668 (203)	420 (12.0)	33 (1.6)	4462 (229)
Other daily to both daily	492 (11.8)	23 (1.3)	3235 (181)	421 (12.0)	27 (1.5)	3780 (199)
Both daily to neither daily	130 (3.1)	26 (2.3)	3599 (325)	110 (3.1)	31 (1.5)	4253 (350)
Both daily to other daily	378 (9.1)	23 (1.5)	3235 (214)	308 (8.8)	28 (1.6)	3970 (244)
Continuously both daily	1427 (34.3)	25 (0.8)	3290 (98)	1207 (34.4)	29 (0.8)	3890 (107)
Change in LTPA						
Continuously inactive	418 (10.1)	28 (1.7)	3723 (238)	346 (9.9)	34 (1.9)	4497 (269)
Inactive to moderately active	362 (8.7)	28 (1.9)	3669 (226)	304 (8.7)	34 (2.1)	4369 (250)
Inactive to active	173 (4.2)	25 (2.5)	3815 (329)	149 (4.2)	30 (2.7)	4429 (357)
Moderately active to inactive	336 (8.1)	31 (2.1)	3877 (246)	288 (8.2)	36 (2.3)	4523 (268)
Continuously moderately active	993 (23.9)	27 (1.0)	3485 (127)	850 (24.2)	32 (1.1)	4071 (138)
Moderately active to active	389 (9.4)	23 (1.3)	3177 (175)	331 (9.4)	27 (1.4)	3734 (190)
Active to inactive	169 (4.1)	25 (2.1)	3520 (301)	145 (4.1)	30 (2.3)	4103 (326)
Active to moderately active	395 (9.5)	26 (1.6)	3608 (211)	335 (9.5)	31 (1.7)	4254 (232)
Continuously active	922 (22.2)	22 (0.9)	3213 (128)	762 (21.7)	26 (1.0)	3887 (144)

Abbreviations: F&V; fruit and vegetable, LTPA; leisure-time physical activity, SA; sickness absence, SD; standard deviation.

Table 3. Cost estimates[a] of changing patterns compared to continuously unhealthy diet and inactive lifestyle.

	Model 1[b]				**Model 2[c]**			
	dy/dx[d]	***p***	**95% CI**		**dy/dx[d]**	***p***	**95% CI**	
Change in F&V consumption								
Neither daily to other daily	-247	0.393	-813	319	-59	0.818	-562	444
Neither daily to both daily	-740	0.015	-1335	-145	-305	0.286	-866	256
Other daily to neither daily	-250	0.409	-844	344	-18	0.948	-552	516
Continuously other daily	-521	0.037	-1012	-30	-199	0.374	-637	239
Other daily to both daily	-805	0.001	-1278	-331	-235	0.297	-678	207
Both daily to neither daily	-183	0.638	-946	579	234	0.522	-482	951
Both daily to other daily	-589	0.026	-1108	-71	-256	0.285	-726	213
Continuously both daily	-675	0.002	-1097	-254	-194	0.318	-576	187
Change in LTPA								
Inactive to moderately active	-117	0.674	-665	431	52	0.843	-466	571
Inactive to active	-414	0.214	-1066	239	-46	0.887	-682	589
Moderately active to inactive	39	0.893	-530	608	-14	0.959	-535	508
Continuously moderately active	-301	0.182	-742	141	-276	0.183	-682	130
Moderately active to active	-857	0.001	-1345	-369	-542	0.022	-1005	-78
Active to inactive	-431	0.191	-1076	214	-294	0.340	-897	310
Active to moderately active	-374	0.159	-895	146	-295	0.228	-773	185
Continuously active	-898	<0.001	-1331	-464	-546	0.009	-954	-137

Abbreviations: CI; confidence interval, F&V; fruit and vegetable, LTPA; leisure-time physical activity.

[a] Employer's direct cost of short-term SA over the 5-year follow-up.

[b] Adjusted for gender, age and work years. The two-part model was used for the analysis. Associations of changes in F&V consumption and SA cost and associations of changes in LTPA with SA cost were examined separately.

[c] Model 1 + SA days during the year before 5-year follow-up period, occupational position, marital status, smoking, binge drinking, sleeping hours and occupational physical work load.

[d] Marginal effects at covariate means are derived from the two-part model which consists of generalized linear model with binomial regression, and generalized linear model with gamma distribution and log-link function.

Estimates in euros of consistently healthier or changing patterns over the follow-up compared to continuously unhealthy diet and inactive lifestyle.

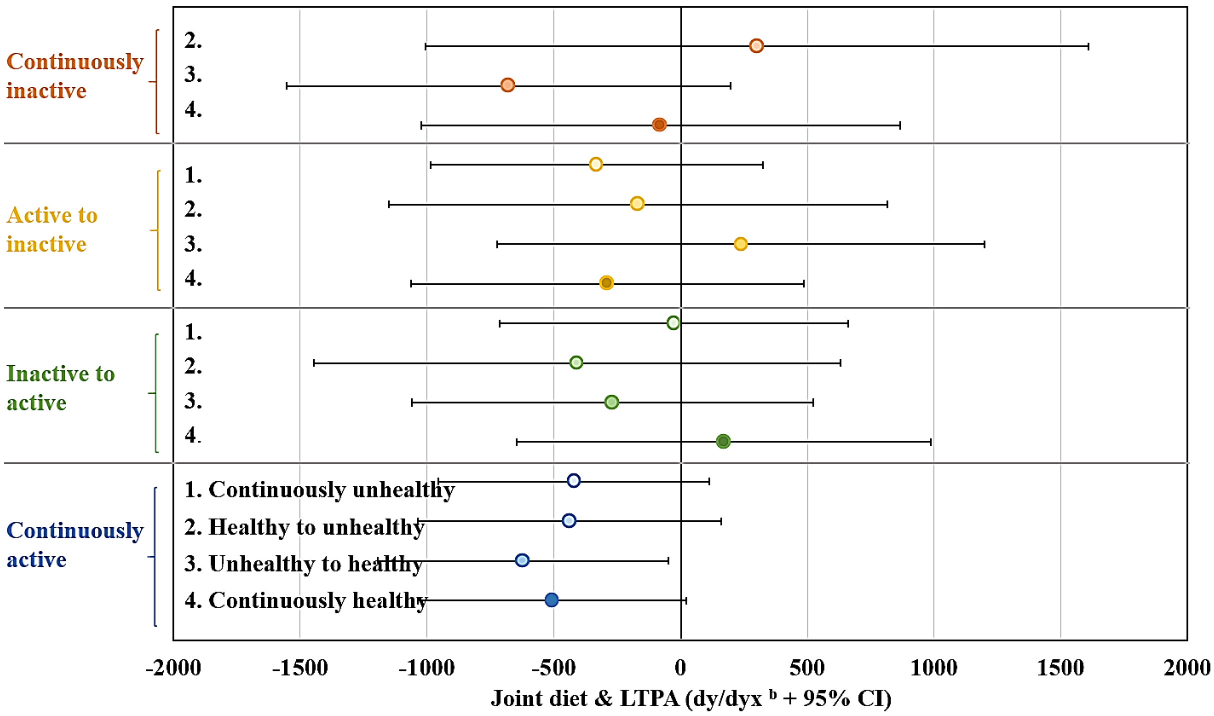

Figure 1. Joint associations of changes in diet[a] and leisure-time physical activity with employer's direct cost (€) of short-term sickness absence over the 5-year follow-up.

Abbreviations: F&V; fruit and vegetable, LTPA; leisure-time physical activity, SA; sickness absence.

[a] F&V consumption is used as an indicator of healthiness of participant's diet, where non-daily F&V consumption represents unhealthy diet and daily F&V consumption healthy diet.

[b] Marginal effects in euros in different joint groups compared to those with continuously unhealthy diet and physical inactivity. Vertical line at zero represents the reference group. Joint variable adjusted for gender, age and work years, SA days during the year before 5-year follow-up period, occupational position, marital status, smoking, binge drinking, sleeping hours and occupational physical work load. The two-part model was used for the analysis.